Ligament of the Head of the Femur in the Orangutan and Indian Elephant

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A literature search revealed that for over 100 years there has been a consensus that the ligament of the head of the femur (LHF) is absent in the orangutan and elephant. A dissection of the hip joints of an adult orangutan and an adult Indian elephant exposed, in each joint, a robust LHF that is functionally important. These LHFs are easily overlooked during a cursory examination of the hip joints because of the way they differ from the human LHF.

INTRODUCTION

The function of the adult human ligament of the head of the femur (LHF) has always been an enigma because its length allows the head of the femur to be completely displaced when the capsule of the hip joint is removed (Fig. 1). In a functional quantitative study of the anatomy of the hip joint in newborn cadavers, I found the LHF to be the most important structure in stabilizing the joint with the lower limbs held in the usual in utero position, wherein the knees and hip joints are fully flexed [1]. I also found that if the LHF is abnormally long the newborn baby is prone to develop congenital or infantile dislocation of one or both hips. When making the literature search for this study I came across published articles stating that the LHF is lacking in all of the amphibians, reptiles, monotremes, hedgehogs, sloths, seals, walruses, elephants, and orangutans [2–14]. Recently, I had the good fortune to have J. Ogden, M.D., and E. Sobert, D.V.M., obtain orangutan and elephant hip joints from the Busch Zoological Gardens, Tampa, Florida, for me to study. The findings of my examination of these joints constitute the essence of this report.

ORANGUTAN *(Pongo pygmaeus)* HIP JOINTS

The hip joints were from a 23- to 26-year-old-male that died of cirrhosis of the liver. First, the capsule of each joint was exposed. The joints were then opened by incising the dorsal half of the capsule along its attachment to the acetabulum. The head of the femur immediately became displaced laterally, pivoting on its ventral attachments to the acetabulum. This change exposed most of the spherical head of the femur that lacked a fovea. A similar exposure of the interior of the adult human hip joint reveals a flat LHF passing from its attachment to the fovea in the center of the femoral head directly to its attachment in the center of the acetabulum, the acetabular fossa (Fig. 1).

Examination of the ventral margin of the head of the femur at its junction with the
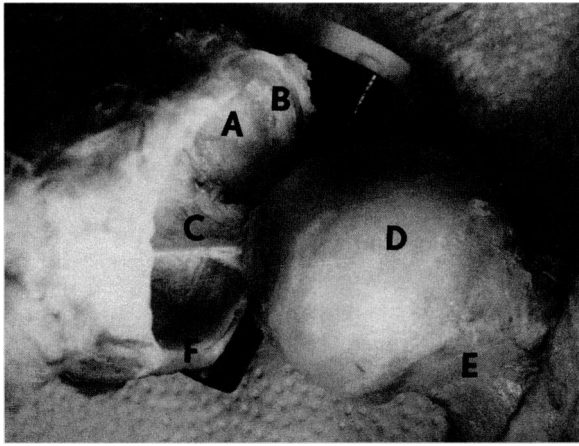
FIG. 1. Anterior view of a left adult human female hip joint with the capsule removed. The LHF (C) is long enough to allow dislocation of the head (D) of the abducted femur: (A) lunate articular cartilage   (B) acetabular labrum   (E) femoral neck (F) transverse acetabular ligament.

neck in the orangutan revealed a broad, thick, flat LHF that passed from an extensive irregular triangular attachment on the head to the adjacent upper medial part of the femoral neck for a distance of 8 mm, where it was firmly attached (Fig. 2). The LHF continues from this attachment on the neck to blend with the transverse acetabular ligament and capsule (Figs. 3,4); it then passes along in the acetabular notch to attach to the bony non-articular fossa of the acetabulum (Fig. 5). This attachment differs from that of the adult human where the flat but relatively less broad LHF passes directly to attach to the bony surface of the acetabular fossa, bypassing the transverse acetabular ligament and acetabular notch (Fig. 1). Only the surface of the orangutan LHF facing the joint space is covered with synovial membrane, whereas the human LHF is sheathed with it.
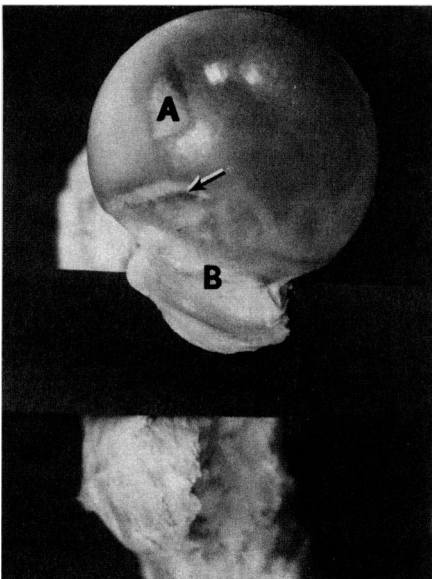

FIG. 2. Medial view of the left femur from an adult male orangutan. The transected LHF (B) attaches to an irregular triangular region of the femoral head (A). An arrow indicates the upper apex of the region. The LHF was freed up from the femoral neck and black paper placed behind it.
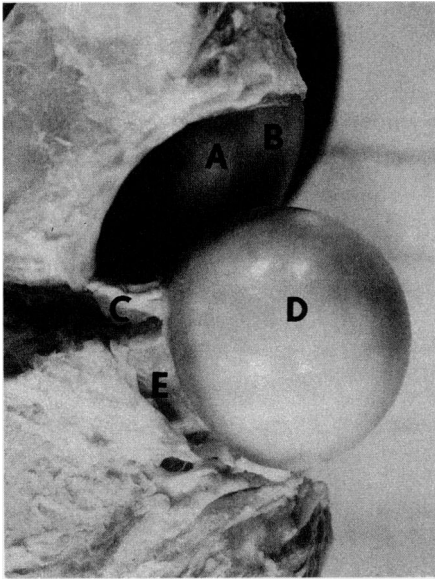
FIG. 3. Anterior view of a left adult orangutan male hip joint with the capsule removed. The dislocated head (D) of the adducted femur is attached to the transverse acetabular ligament by the LHF (C). The attachment of the LHF to the femoral neck (E) was freed up: (A) lunate articular cartilage (B) acetabular labrum.

INDIAN ELEPHANT *(Elephas indica)* HIP JOINTS

These hip joints were those of a 14-year-old female that died of "natural causes." A robust LHF was found in each joint; each was similar to that of the orangutan in that it attaches to the ventral border of the femoral head at its junction with the neck (Fig. 6). The attachment is, however, a relatively smaller triangular area than that of the orangutan. The elephant LHF is relatively thicker and more cord-like than that of the orangutan and the adult human. The elephant LHF is not attached to the short,
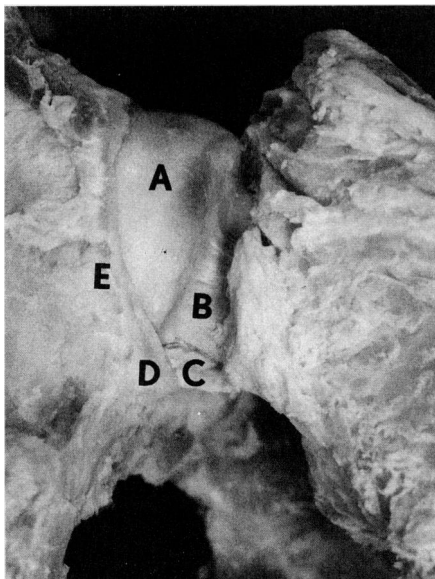

FIG. 4. Anterior view of the orangutan hip joint shown in Fig. 3. The femur is abducted. The taut LHF (C) attached to the femoral neck (B) and transverse acetabular ligament (D) causes the femoral head (A) to fit snugly into the acetabulum (E) acetabular labrum.
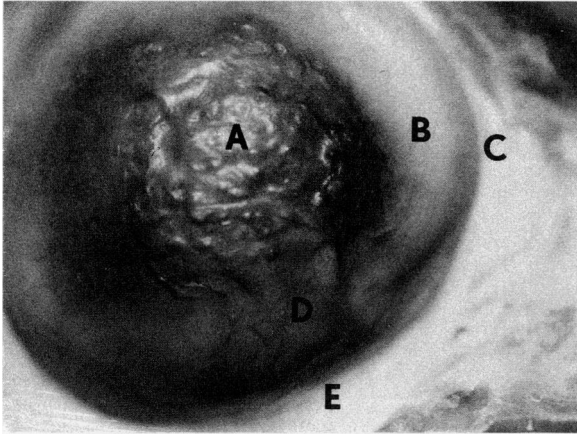
FIG. 5. Lateral view of an acetabulum from a left hip joint of an adult male orangutan. The joint capsule was removed and the LHF transected where it blended with the transverse acetabular ligament (E) and capsule: (A) acetabular fossa (B) lunate articular cartilage (C) acetabular labrum (D) LHF in the acetabular notch.

vertically oriented femoral neck because it passes directly to the acetabulum to fuse with the transverse acetabular ligament and the surface of the acetabular notch on its way to end on the bony surface of the acetabular fossa. The elephant LHF is sheathed with synovial membrane as it passes from the femoral head to the acetabulum. From there on, only its surface facing the joint space is covered with synovial membrane along the acetabular notch and fossa attachments.

DISCUSSION

Hegetor [7], a surgeon at Alexandria, Egypt, in 100 B.C., was the first to describe the LHF in humans. This description probably influenced subsequent investigators in assuming that a LHF was absent when the hip joint of an animal was opened and no ligament was observed bridging the joint cavity from the center of the femoral head to the center of the acetabulum.

The supposed lack of an LHF in the orangutan has long been associated with the great mobility of the hind limbs. In 1837, J.F. Palmer [8] stated, "In the orang, the lower limbs are feebly developed as organs of support, but have a great extent of motion, the hip joint being, like the shoulder joint, without a round ligament." In 1988, J.T. Stern [11] states, "The ligamentum teres is too slender a band to have any effect
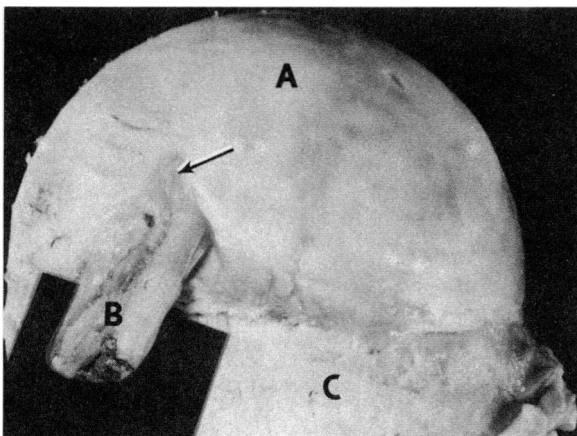

FIG. 6. Medial view of the head (A) of a left femur from an adult female Indian elephant. The transected LHF (B) attaches to a triangular region of the head at its junction with the short, vertically oriented femoral neck (C). An arrow indicates the upper apex of the triangular region. Black paper lies between the LHF and the neck.

on hip motion in humans. Furthermore, it tends to become tight only in very peculiar positions. That it might be a nuisance if it were to adopt such peculiar positions with regularity is evinced by orangutans, which are the only primates to lack a ligamentum teres and who also have an extraordinary mobile hip enabling the assumption of bizarre postures in the trees." I conclude that the LHF in the orangutan is one of the most important structures that acts to prevent hip dislocation when the hind limb assumes bizarre positions, especially when an orangutan suspends itself vertically, by holding on with its hands and feet to the narrow, branchless trunks of adjacent trees over 40 feet in height. As the trees move apart, the extended lower limbs can abduct until they are nearly at right angles to the body. The LHFs are then at their maximum tautness. The amount of tension the LHFs are subjected to in this position can be considerable in a male weighing 200 pounds (90.7 kg) or more. In abduction, the femoral head pivots on the LHF attachment to it and its neck to drive the head snugly and firmly into the acetabulum (Fig. 4).

The LHFs in the elephant are also the primary structures that function to prevent dislocation of the hip joints when it spreads or abducts its hind limbs. The typical position of the hind limbs of mammalian quadrupeds when standing is with the hip and knee joints in partial flexion; this attitude requires a considerable amount of continuous limb muscle contractions to maintain the standing position. The elephant and the human are exceptions because when they stand, the elephant on four limbs and the human erect on two, the hip and knee joints are fully extended [16]. The elephant femur has a very short neck and the head faces vertically to fit into a downward-facing acetabulum when the elephant stands on all fours. Little and, at times, no muscle contractions occur in the standing human and elephant because the passive ligaments supporting the hip, knee, and ankle joints bear the brunt of the forces exerted at these joints in the standing position. In the elephant and the human, the hip joint capsule is twisted as the joint is extended. This movement shortens the capsule and "screws" the femoral head snugly into the acetabulum. The ligaments that are directly fused to the capsule externally, the iliofemoral, pubofemoral, and ischiofemoral, become maximally taut as they become twisted. These ligaments are the primary structures that function to prevent hip dislocation in the human because the LHF is not taut in the extended hip.

In contrast, in the elephant, the largest land animal, the LHF gives significant assistance to the capsular ligaments in supporting the hip joint when the animal stands on all four limbs. The LHF becomes the primary support of the hip joint when the hind limb is abducted. The LHF functions similarly to that of the orangutan in that, as it becomes taut, it drives the femoral head snugly into the acetabulum (Fig. 4). An extreme example occurred when I saw a circus elephant stand erect on only one hind limb. In this position the tensional stress on the LHF of the abducted hip joint supporting the entire body can be considerable in an elephant weighing six tons (5.4 mt) or more.

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